

Hawaii Agricultural Research Center (HARC)

sUAS Flight Operations Manual

For operations with the E616S Agriculture UAS, JIYI K++ V2 Flight Controller, AK28 android smart controller, and Agri Assistant application.

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Introduction

An Unmanned Aerial System (UAS) encompasses the unmanned aircraft (UA) and all of the associated support equipment, ground control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft. The UA is the flying portion of the system, flown by a pilot via a ground control system, or autonomously through use of an on-board computer, communication links and any additional equipment that is necessary for the UA to operate safely. The Federal Aviation Administration (FAA) issues an experimental airworthiness certificate for the entire system, not just the flying portion of the system. Under 49 United States Code 40103, the United States Government has exclusive sovereignty of airspace of the United States and the FAA has the authority to prescribe air traffic regulations on the flight of aircraft, including UAS.

Public Aircraft Operations are limited by federal statute to certain government operations within U.S. airspace. Title 49 U.S.C. § 40102(a)(41) provides the definition of "Public Aircraft" and § 40125 provides the qualifications for public aircraft status. Whether an operation qualifies as a public aircraft operation is determined on a flight-by-flight basis, under the terms of the statute. The considerations when making this determination are aircraft ownership, the operator, the purpose of the flight, and the persons on board the aircraft.

For public aircraft operations, the FAA issues a Certificate of Waiver or Authorization (COA) that permits public agencies and organizations to operate a particular aircraft, for a particular purpose, in a particular area. The COA allows an operator to use a defined block of airspace and includes special safety provisions unique to the proposed operation. COAs usually are issued for a specific period – up to two years in many cases.

The FAA works with these organizations to develop conditions and limitations for UAS operations to ensure they do not jeopardize the safety of other aviation operations. The objective is to issue a COA with parameters that ensure a level of safety equivalent to manned aircraft. Usually, this entails making sure that the UAS does not operate in a populated area and that the aircraft is observed, either by someone in a manned aircraft or someone on the ground to ensure separation from other aircraft in accordance with right-of-way rules. Common public uses today include law enforcement, firefighting, border patrol, disaster relief, search and rescue, military training, and other government operational missions.

The FAA manages public aircraft COAs through its COA Online system. Before the FAA grants an agency access to COA Online, the agency (or proponent) will be asked to provide the FAA with a "declaration letter" from the city, county, or state attorney's office assuring the FAA that the proponent is recognized as a political subdivision of the government of the State under Title 49 of the United States Code (USC) section (§) 40102(a)(41)(c) or (d) and that the proponent will operate its unmanned aircraft in accordance with 49 USC. § 40125(b) (not for commercial purposes). An agency's accountable executive cannot self-certify their agency is a "public" agency.

If an activity does not fall under the purview of "government function", which includes "activities undertaken by a government, such as national defense, intelligence missions, firefighting, search and rescue, law enforcement (including transport of prisoners, detainees, and

illegal aliens), aeronautical research, or biological or geological resource management", it does not qualify as a public operation. Three relevant documents to consult in determining if your work is considered a public operation are *Advisory Circular 00-1.1A, Public Aircraft Operations, UAS Operations by Public Universities for Aeronautical Research*, and *Clarification of June 13, 2014 Interpretation on Research Using UAS*. The important point of these documents is that the term "aeronautical research" is a very limited term and cannot be manipulated to include any manner of research that an operator may seek to undertake.

The UAS COA process is managed in Washington, DC, FAA Headquarters in the UAS Group (AJV-13). Contact AJV-13 via email for assistance. The process includes opening a COA website account, which has an application that can be populated on-line. Public aircraft are tied to government agencies, therefore credentials must be provided.

A public aircraft is one that is only for the United States government or owned and operated by the government of a state, the District of Columbia, or a territory or possession of the U. S. or a political subdivision. Operators of public aircraft include DOD, DOJ, DHS, NASA, NOAA, state/local agencies and qualifying universities. Civil aircraft means other than a public aircraft.

There are presently three methods of gaining FAA approval for flying civil (non-governmental) UAS:

1. Special Airworthiness Certificates – Experimental Category (SAC-EC) for civil aircraft to perform research and development, crew training, and market surveys. However, carrying persons or property for compensation or hire is prohibited. For more information, please contact the Airworthiness Certification Service, AIR-113, at 202-267-1575. 1,3
2. Obtain a UAS type and airworthiness certificate in the Restricted Category (14 CFR § 21.25(a)(2) and § 21.185) for a special purpose or a type certificate for production of the UAS under 14 CFR § 21.25(a)(1) or § 21.17. 7,8
3. Petition for Exemption with a civil Certificate of Waiver or Authorization (COA) for civil aircraft to perform commercial operations in low-risk, controlled environments.

By law, any aircraft operation in the national airspace requires a certificated and registered aircraft, a licensed pilot, and operational approval. Section 333 of the FAA Modernization and Reform Act of 2012 (FMRA) (PDF) grants the Secretary of Transportation the authority to determine whether an airworthiness certificate is required for a UAS to operate safely in the National Airspace System (NAS).

This authority is being leveraged to grant case-by-case authorization for certain unmanned aircraft to perform commercial operations prior to the finalization of the Small UAS Rule, which will be the primary method for authorizing small UAS operations once it is complete.

The Section 333 Exemption process provides operators who wish to pursue safe and legal entry into the NAS a competitive advantage in the UAS marketplace, thus discouraging illegal operations and improving safety. It is anticipated that this activity will result in significant economic benefits, and the FAA Administrator has identified this as a high priority project to address demand for civil operation of UAS for commercial purposes.

Pilot certification requirements for petitions for exemption under Section 333 are evaluated on a case-by-case basis. While Section 333 grants the Secretary of Transportation flexibility with regard to airworthiness certification requirements, it does not grant the Secretary any flexibility with regard to airman certification standards as outlined in Sections 44703 and 44711 of Title 49 of the United States Code (49 USC). An FAA airman certificate is **required** to operate an aircraft in the National Airspace System.

Registration is required for all unmanned aircraft (UA) operated for non-hobby or non-recreational purposes. Registration is also required for Government UA. All Aircraft owned by agencies, offices or subdivisions of: the United States (other than aircraft of the U.S. Armed Forces), the States, the District of Columbia, or a territory or possession of the United States are required to be registered. Aircraft Registration requirements and directions are provided in 14 Code of Federal Regulations Part 47. In general registration requires:

- A completed Aircraft Registration Application, AC Form 8050-1
- A full description of the sUA (consult 14 Code of Federal Regulations Part 47 for required items)
- Evidence of Ownership
- Confirmation the sUA is not registered in another country
- An N-number to be assigned to the registered aircraft
- The registration fee of \$5.00 per aircraft

The FAA will grant a Certificate of Waiver or Authorization (COA) for flights with a elevation ceiling at or below 200 feet above ground level to any UAS operator with a Section 333 exemption for UA weighing less than 55 pounds, operate during daytime Visual Flight Rules (VFR) conditions, within visual line of sight (VLOS) of the pilots, and from established, minimum safe distances from airports or heliports:

- 5 nautical miles (NM) from an airport having an operational control tower; or
- 3 NM from an airport with a published instrument flight procedure, but not an operational tower; or
- 2 NM from an airport without a published instrument flight procedure or an operational tower; or
- 2 NM from a heliport with a published instrument flight procedure

The “blanket” 200-foot COA allows flights anywhere in the country except restricted airspace and other areas, such as major cities, where the FAA prohibits UAS operations (<http://www.faa.gov/news/updates/?newsId=82245>). Section 333 exemption holders automatically receive a “blanket” 200 foot COA. Anyone who wants to fly outside the blanket parameters must obtain a separate COA specific to the airspace required for that operation.

Purpose

This HARC, Flight Operation Manual (FOM) details safety guidelines, limitations, checklists, normal procedures, supplemental procedures, and non-normal procedures for the operation of sUAS. The essential sections of this FOM pertain to normal operation. When configurations, including hardware and software, or actions outside of normal operations are utilized, the pilot is referred to the appropriate manufacturer's manual.

Safety Guidelines

1. All flight operations will be accompanied by a flight plan detailing the mission objective, location, crew, resources and contingency protocols for go/no go decision and pilot alternation.
2. A briefing with preflight checklist will be conducted at the landing zone (LZ) for establishing go/no go determination, radio check with NOTAM, reviewing mission objectives, acknowledging crew assignments, equipment (e.g., UAS) calibration and emergency action plans.
3. The basic crew of a sUAS flight operation consists of a Pilot In Command (PIC), at least one Visual Observer (VO) and Ground Support Staff (GSF).
4. The Pilot In Command (PIC) maintains operational control of UA via radio link, and is the final authority for all operational and in-flight decisions.
5. The PIC and VO must have constant audio communication during operations either unaided at close proximity or via radio at larger distances. If the latter, the PIC and VO must maintain visual contact with each other.
6. In an in-flight emergency requiring immediate action, the PIC may deviate from any rule of this manual to the extent required to meet that emergency.
7. Each PIC who deviates from a rule under guideline (2) of this section shall, upon the request of the Federal Aviation Administration (FAA), send a written report of that deviation to the FAA. A written report according to the Hazard/Incident Report must be submitted to HARC administration.
8. All accomplished missions will be logged with PIC as signatory identifying basic metrics regarding UA maintenance, flight time and objective completion and should highlight any deviations from the original flight plan.
9. All operations must be conducted according to all HARC documentation and FAA approvals.
10. All operations must be compliant with sterile area/airspace control procedures according to HARC documentation.
11. The PIC must always give way to manned aircraft.
12. Training of every PIC will take place according to HARC documentation and FAA approvals.
13. Any unapproved modification of the UA is prohibited.

E616S UAS General Specifications

Frame parameter	
E616S	E610S
Wheelbase: 1628mm	Wheelbase: 1404mm
Opened size: 1720*1500*556mm	Opened size : 1495*1308*500mm
Folded size: 1073*956*546mm	Fold size: 945*848*500mm
Tank capacity: 16L	Tank capacity: 10L
Frame weight: 7kg	frame weight: 5kg

Recommended Motor	
E616S	E610S
Motor: X8、8118	Motor: X6、6215
Propeller: 28-32inch	Propeller: 23-24inch
ESC: 80A FOC	ESC: 80A FOC
Maximum takeoff weight: 36kg	Maximum takeoff weight: 25kg
Supply voltage: 12S	Supply voltage: 12S

Governor
Parameter Size:
47*34*24mm Weight: 72g
Mounting pitch: 54-60mm
Supply voltage: 15-60V
Output voltage: 12V
Maximum current: 6A
Maximum power: 72W
Range of travel: 1120-1920 μ s
Signal: full—— high level empty——Low level
The 3pin line is connected to the flight control level gauge detection interface. The drug break signal is output with high and low level signals. The water is high level and the no-water is low level. Before taking off, the air in the water pump needs to be discharged to avoid mistakes after takeoff

Limitations

Pilot

- Pilots consist of the designated Pilot in Command (PIC) and Supplemental Pilots
- UA pilots must meet the qualifications listed in FAA Order 8900, 16-4-1-3
- Pilots must undergo training with the specific sUAS, by reviewing the attached supplemental documents (E616S Agriculture Manual, JIYI K++ V2 Flight Controller Manual, AK28 Android Smart Controller Manual, and Agri Assistant Application Manual). The E616S will be piloted by FAA certified Part:107 operators in as in accordance to FAA required training for certified airmen. Training will consist of observing and performing all of the activities listed in the following procedures, including the Non-Normal Procedures, with additional training for any added sensor payloads.

Pilot in Command

- Has been designated prior to flight
- Is responsible for the UAS flight operation as described under 14 CFR part 91, § 91.3, or an FAA-recognized equivalent
- Is responsible for determining whether the UAS is in condition for safe flight.
- Must land as soon as safely practical when any condition occurs that causes operations to be unsafe
- May be augmented by supplemental pilots; however, the PIC retains complete and overall responsibility of the flight, regardless of who may be piloting the aircraft
- Has the ability to assume the duties of an internal or an external UAS pilot at any point during the flight
- May rotate duties as necessary to fulfill operational requirements
- Must have audio and visual contact with VOs
- Must have a thorough knowledge of the Certificate of Waiver or Authorization (COA) issued to the organization when conducting a public aircraft operation, and must retain a copy to reference during flight
- Must be trained and qualified on the specific UAS for the conduct of the flight
- For further information consult FAA Order 8900, 16-4-1-1-B

Visual Observers (VOs)

- A VO is a trained person who assists the unmanned aircraft pilot in the duties associated with collision avoidance. This includes, but is not limited to, avoidance of other traffic, clouds, obstructions and terrain
- All VOs must have an understanding of the Title 14 of the Code of Federal Regulations (14 CFR) parts applicable to the airspace where the Unmanned Aircraft Systems (UAS) will operate

- VOs are considered crewmembers
- Observers must not perform crew duties for more than one UAS at a time
- VOs must have audio and visual contact with PICAll observers must have a valid Federal Aviation Administration (FAA) second-class medical certificate issued under 14 CFR part 67 verifying that the observer has sufficient visual and auditory acuity; an FAA-recognized equivalent is an acceptable means of demonstrating compliance with this requirement
- Observers must complete sufficient training to communicate to the pilot any information required to remain clear of conflicting traffic, terrain, and obstructions; maintain proper cloud clearances; and provide navigational awareness. Consult FAA Order 8900, 16-4-4-1-B for minimum requirements.

Flight Operation Procedures

- If the UA is assembled prior to flight, the PIC must perform a Pre-Flight Checklist
- A safe distance should be maintained from people and obstacles as detailed in the Manufacturer's Safety documentation
- All operations must be within Line Of Sight (LOS)
- All operations must be at or below 200 ft AGL (unless an additional civil COA is filed)
- All manned aircraft have the right of way
- Operations must be conducted in accordance with the Manufacturer's Operation Manual
- Operation in adverse weather such as, but not limited to, rain, wind or fog is prohibited
- Every effort should be made to avoid interference resulting in a loss of communication between the remote control transmitter and other wireless equipment
- Sufficient battery voltage (at least 25%) for Landing and Non-Normal Procedures must be maintained during operations

Batteries

- Flammable if damaged and must be charged under supervision
- Discharging Lithium Polymer Batteries (in A) in excess of 80% of their rated capacity (in A-hr) can cause permanent damage to the batteries
- Provide time for batteries to cool to within 5°F of the ambient temperature after use and before subsequent charging
- Use batteries of the appropriate rating as given in the Manufacturer's manual

Navigation

- GPS signals are limited by line of sight. Autonomous operations must be conducted under conditions that ensure obstructions to the sky are minimized, and must have a pilot ready to assume remotely operated control at all times.
- Gyroscopes are subject to drift due to compounding integration errors. The gyroscope must be calibrated prior to launch.
- Magnetometers (compasses) must be calibrated prior to launch

- Barometric altimeters must be calibrated for ambient conditions at a known altitude prior to launch
- Laser altimeters may require calibration if the sUAS is flown over terrain with a significantly different reflectance at the wavelength of the transmitted signal. Consult the Manufacturer's Model

Operational Environment

- Flight in visible moisture and other conditions that affect LOS is prohibited

Other Personnel

- Any additional personnel must meet qualifications listed in FAA Order 8900, 16-4-4-3

Storage, Transport and Disposal of Pesticides

- Pesticides should be kept in a secure, locked place to which children, animals or unauthorized people do not have access. They should not be stored in living or sleeping quarters and should be kept separately from all food, including animal feed, and away from water and water supplies. They should be kept dry and out of direct sunlight and excessive heat or cold. Pesticides storage areas should be away from naked flame or equipment that generates sparks. Storage places should be well ventilated and bunded or otherwise able to ensure the containment of spills. Pesticides should never be transferred into containers other than those in which they were supplied.
- The quality of the pesticide packaging should be adequate for the distance and type of journey that has to be made to the spray site. Never transport pesticides in the passenger area of a vehicle; instead, place them in the trunk or truck-bed. Do not bag pesticides with groceries or other household items, or carry them in the same area of a vehicle to avoid accidental contamination. Make certain pesticide container lids are securely fastened. Secure containers in an upright position to ensure they cannot fall or be knocked over. Boxes and other packing materials may be useful. Protect pesticides from extreme hot or cold temperatures. Temperature extremes can damage containers and cause chemicals to lose effectiveness. Never leave pesticides unattended in an unlocked trunk or open truck bed to prevent contact by children or others.
- As pesticide containers are emptied, while wearing PPE, fill the pesticide container ¼ full of clean water, replace cap and shake container for 30 seconds. Pour rinse water into the spray tank. Repeat the cleaning two additional times, shaking the container in different directions. Carefully rinse the outside of the container and the cap, catching the rinsate in a bucket and return it to the spray tank. Dispose of the cap as regular household waste and dispose of or recycle containers according to local regulations. Apply the diluted rinse material to the treated area according to label directions.

Normal Procedures

Flight Planning Checklist

1. The PIC must issue a Notice to Airmen (NOTAM) not more than 72 hours in advance, but not less than 48 hours prior to the operation
2. Contact Visual Observers to confirm that they have not consumed any alcoholic beverage 8 hours prior to flight in compliance with Title 14 CFR part 91, § 91.17

Weather

1. Consult local weather report for the day of the operation, at least 72 hours in advance
2. If inclement weather is indicated in the local weather report in advance of operations, an additional report must be consulted 24 hours prior to operation
3. For further information consult the FAA's *General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making*

Flight Planning Checklist Complete

Pre-Flight Checklist

Site Set Up

1. Check NOTAMS for Temporary Flight Restrictions, GPS NOTAM (<https://pilotweb.nas.faa.gov/PilotWeb/>)
2. Verify that local weather is within operating parameters of the sUAS and that the PIC and VOs can maintain LOS with the sUAS at all points of the operational area
3. Verify that all operational documents, including flight manuals, are present and accessible to all personnel
4. Conduct a briefing with all personnel to discuss the operational plan, including all Non-Normal Procedures
5. PIC and VOs should consult the operational manual prior to operation to review relevant responsibilities and procedures as they pertain to the operation plan
6. Designate PIC and VO locations
7. Designate Launch, Landing, and Non-Normal Landing Zones. Verify that these areas are clear of any obstructions and apply a visual mark.
8. PIC and VOs must visually inspect the operational area to verify that only operational personnel are present

UAS Set Up

1. Verify that the sUAS is free of visible defects
2. Verify that all propellers are in good condition: free of cracks, holes, other defects
3. Verify that all propellers are firmly mounted by moving the propellers gently while holding the motor
4. Verify that proper mounting direction of IMU and GPS
5. Verify that control link is stable
6. Perform Navigation Calibration Procedure
7. Verify that motor rails are firmly attached

8. Verify that all screws are tightened securely
9. Verify that landing gear is firmly attached
10. Verify that all antennas are firmly attached and in optimal operating position
11. Verify that all batteries are fully charged
12. Verify motors are rotating propellers in the correct direction

Pre-Flight Checklist Complete

Launch Checklist

1. Verify that the UA is in proper alignment for launch
2. Alert all personnel for launch
3. Verify that the surrounding airspace is clear and that the launch zone is clear of obstructions
4. Initiate launch sequence as prescribed in Manufacturer's Manual

Launch Checklist Complete

Landing Checklist

1. Verify that the UA is in proper landing position both with navigational data and visually
2. Alert all personnel for landing
3. Verify that the surrounding airspace is clear and that the landing zone is clear of obstructions
4. Initiate landing sequence as prescribed in Manufacturer's Manual

Landing Checklist Complete

After Landing Checklist

1. Turn data collection device(s) off
2. Turn UA off
3. Turn controller off
4. Inspect UA for damage

After Landing Checklist Complete

Shut Down/Secure Checklist

1. Secure antennas in transport position
2. Transfer operational data, including flight path, to appropriate media storage
3. Complete Post Flight documentation (i.e., flight log)

Shut Down/Secure Checklist Complete

Appendix 1. Hazard/Incident Report

HARC Accident/Incident Report

ACCIDENT ☐ INCIDENT ☐

DATE OF EVENT

____/____/____

LOCAL TIME

LOCATION: CITY/STATE/ZIP

PIC NAME

DEPARTMENT

DATE OF BIRTH

____/____/____

HOURS IN UAS (LAST 90 DAYS) ____

HOURS IN UAS (LAST YEAR) ____

HOURS IN UAS (TOTAL) ____

CERTIFICATION: TYPE/NO

OTHER PERSONNEL: NAME/ROLE

INJURIES: NAME/ROLE/SEVERITY
(ATTACH ADDITIONAL SHEETS AS
NECESSARY)

SUAS DAMAGE:

NONE ☐

MINOR ☐

SUBSTANTIAL ☐

DESTROYED ☐

UAS REGISTRATION NO.

MAKE/MODEL

YEAR OF MANUFACTURE

NARRATIVE

(ATTACH ADDITIONAL SHEETS AS
NECESSARY)

Appendix 2. FAA UAS Regulations & Policies

Presidential Guidance and Laws

- Presidential Memorandum: Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems
- Public Law 112-95, Title III, Subtitle B – Unmanned Aircraft Systems (FAA Modernization and Reform Act of 2012)

Title 14 Code of Federal Regulations

- Part 1, Definitions, Civil Aircraft, section 1.1
- Part 21, Certification Procedures for Products and Parts
- Part 21, Subpart H, Airworthiness Certificates, Experimental Certificates, sections 21.191 and 21.193

Rules

- Interpretation of the Special Rule for Model Aircraft

Advisory Circulars

- AC 00-1.1A, Public Aircraft Operations
- AC 91-57, Model Aircraft Operating Standards
- AC 21-12, Application for U.S. Airworthiness Certificate, FAA Form 8130-6
- AC 45-2D, Identification and Registration Marking

Policies

- Notice 8900.291, Inspection and Maintenance Program Requirements for Airworthiness Certification of Unmanned Aircraft Systems Operating Under 55 Pounds
- Notice 8900.292, Aviation-Related Videos or Other Electronic Media on the Internet
- UAS Temporary Flight Restrictions (TFRs) for Sporting Events
- 2007 Federal Register Notice, Unmanned Aircraft operations in the National Airspace System
- Notice 8900.313 Education, Compliance, and Enforcement of Unauthorized Unmanned Aircraft Systems Operators
- UAS Certification Status, November 15, 2006, includes FAA focal points for UAS certification project coordination
- UAS Certification Status, Optionally Piloted Aircraft and Accidents Involving UAS, August 18, 2008, Revision to AVS Policy

Orders

- Order 8000.372A, UAS Designated Airworthiness Representatives (DAR) for UAS Certification at UAS Test Sites
- Order 1110.150, Small Unmanned Aircraft System Aviation Rulemaking Committee (ARC)
- Order 2150.3B, Change 6 (Compliance and Enforcement Bulletin)
- Order 8130.2, Airworthiness Certification of Aircraft and Related Products
- Order 8130.20, Registration Requirements for the Airworthiness Certification of U.S. Civil Aircraft
- Order 8130.34C, Airworthiness Certification of Unmanned Aircraft Systems
- Order 8900, Volume 16, Unmanned Aircraft Systems

FAA Legal Interpretations on Unmanned Aircraft Systems

- New Media Use of UAS
- Clarification of June 13, 2014 Interpretation of Research Using UAS
- Operation of UAS as Public Aircraft for Educational Purposes
- Interpretation regarding whether certain required documents may be kept at an unmanned aircraft's control station

Guidance

- Law Enforcement Guidance for Suspected Unauthorized UAS Operations
- Letter to COA Holders – Statutory Requirement to Register UAS (November 5, 2014)
- Public Guidance for Petitions for Exemption Filed under Section 333

Forms

- FAA Form 8130-6, Application for U.S. Airworthiness Certificate

Appendix 3: List of Acronyms

Hawaii Agriculture Research Center	HARC
UAS	Unmanned Aerial System
UA	Unmanned Aircraft
sUAS	Small Unmanned Aerial System
FOM	Flight Operations Manual
FAA	Federal Aviation Administration
PIC	Pilot In Command
LOS	Line Of Sight
NOTAM	Notice to Airmen
GPS	Global Positioning System
IMU	Inertial Measurement Unit
VO	Visual Observer